J. Plant Production, Mansoura Univ., Vol. 5 (9): 1557-1572, 2014

RESPONSE OF BLACK CUMIN (*Nigella sativa* L.) PLANT FOR NATURAL SOURCES OF PHOSPHORUS AND SOME FOLIAR APPLICATION.

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ABSTRACT

A field experiment was conducted at Gemmeiza Agricultural Research Station, Agric. Res. Center, El- Gharbia Governorate during two successive winter seasons (2011/2012 and 2012/2013) to study the effect of natural sources of phosphorus (Phosphorien and Rock phosphate) at three levels (50, 75 and 100 %) of the recommended dose (RD) and foliar application of Super Mex or Power Mix on some vegetative growth parameters, seed yield, fixed oil yield and chemical compositions in seeds of black cumin (*Nigella sativa* L.) plant.

The obtained results revealed that :

1- The highest values of plant height, capsules number/plant, seeds number/capsule, capsules weight/plant, 1000-seed weight, seed yield and fixed oil yield were achieved from the treatment of 50 % (Phosphorien plus Rock phosphate) + 50 % NPK in both seasons, while 75 % (Phosphorien plus Rock phosphate) resulted in the highest plant dry weight and chemical constituents content.

2- Spraying with Super Mex (RD) + 50 % NPK resulted in the highest values of vegetative growth characters, seed yield, fixed oil of percentage, yield and chemical constituents in comparison with the foliar spray of Power Mix (RD) and the control treatments in both seasons.

3- The interaction treatment of 75 % (Phosphorien plus Rock phosphate) + Super Mex + 50 % NPK augmented values of plant height, capsules number/plant, seeds number/capsule, capsules weight/plant, 1000-seed weight, seed yield, fixed oil yield and chemical constituents in both seasons, while Phosphorien plus Rock phosphate (50 %) induced in the highest plant weight.

Keywords: *Nigella sativa* L. plants, foliar application, biofertilizers, seed yield, fixed oil, NPK.

***recommended dose (RD)**

INTRODUCTION

Black cumin (*Nigela sativa* L**.**) is an annual herbaceous plant of the family *Ranunculaceae.* The plant is native of S. Europe, N. Africa and SW Asia, but extensively cultivated in India. The seeds contain 2 kinds of oils; one dark-coloured fragrant and volatile, the other clear, nearly colourless and about the consistency of castor oil. Medicinally, both the oils are regarded as aromatic, carminative, stomachic and digestive. The seeds are diuretic, digestive, carminative, emmenagogus, kill intestinal worms and relieve flatulence. Also used in cases of stone in bladder and kidneys, as well as in chronic fever due to phlegm, rheumatism, gout and sciatica, (Gupta, 2010).

Crop yield of all higher plants is frequently constrained by availability of major nutrients including phosphorus. Phosphorus is one of essential nutrients required by both plant and microorganisms, their major physiological roles are the accumulation and release of energy during cellar metabolism, (Marchner, 1995). Phosphorus fertilizers are expensive, so, we have been reduced the amount applied and /or solubility the phosphorus in the soil. Also, the supply of P to crops can only be increased by additions of manure, Rock phosphate or inorganic fertilizers.

The P fertility problems could possibly be decreased by applying P as a Rock phosphate, (Ayaga *et al.*, 2006). In addition, soluble phosphate combination with cation in soil solution to form low solubility substances is called phosphate fixation which improves net photosynthesis. Naguib and Khalil (2002) pointed out that Phosphorien at 7kg/fed increased number of capsules/plant, number of seeds/ capsule, 1000-seed weight and seed yield on *Nigella sativa* L. plants. Helmy (2003) observed that application of Phosphorien biofertilizer plus half dose of NPK-recommended rate, positively affected growth characters of *Hibiscus sabdariffa* L. plants when compared with those fertilized by full dose of NPK (RD). Shalan (2005) revealed that the mixture of all biofertilizer treatments at the rate of 7kg /fed increased plant height, number of branches / plant, number of capsules/ plant, seed yield, volatile and fixed oil percentage and yield of *Nigella sativa* L. plants. Abdou *et al.* (2011) found that biofertilization treatments led to an increasing of N, P and K % in the leaves of clove basil plants. Monip *et al.* (1982) claimed that the group of micro-organisms seem to play an important role in the soil fertility and are capable of producing certain growth promoting substances as hormones, amino acids and vitamins.

Micronutrients are needed in very small quantities for good plant growth; their deficiencies cause great disorders in the physiological and metabolic process of laveder plant. Its beneficial effect on plant growth is based on improving carbohydrates, nitrogen metabolism and photosynthesis, enhancement of the plant resistance and involvement in the centers of enzymes and vitamins, (Shoala, 2000). Ahmed *et al.* (1997) mentioned that active dry yeast as a foliar fertilizer enhanced growth and plants nutritional status. Mohamed and Naguib (2002) revealed that foliar application with ascorbine increased significantly weight of 1000 seeds and seed yield/ plant and/ fed in the fenugreek. Naguib and Khalil (2002) recorded that the growth, 1000 seeds weight, seed yield and chemical constituents N, P and K content of *Nigella sativa* L. plants were the highest with the application of 2g/L active yeast. Ahmed (2007) reported that the application of active yeast to *Nigella sativia* L. plants increased number of capsules / plant, weight of 1000 seeds, seed yield**/** plan, volatile and fixed oil percentage and yield compared with control plants. Ghally and El-Sodany (2009) mentioned that the best effects of spraying active dry yeast 2g/L were observed on all the studied parameters of *Niglla sativa* L. plants compared to unsprayed plants.

This investigation aimed to study the effect of such variant of different fertilizers and find out the best treatment of fertilization form through using natural sources of Phosphorus e.g. (Phosphorien and Rock phosphate) and foliar application (Super Mex and Power Mix) as well as their interactions on some vegetative growth parameters, seeds yield, fixed oil yield and chemical compositions of *Nigella sativa* L.

MATERIALS AND MOTHEDS

The present study was conducted during the two successive winter seasons of (2011/2012 and 2012/2013) at the Farm of Agricultural Research Station in Gemmeiza,, Agric. Res. Center El- Gharbia Governorate and Laboratory of Veg. and Flori. Dept. Fac. Agric. Mansoura Univ. to study the effect of natural sources of phosphorus (Phosphorien plus Rock phosphate) in addition to foliar application of Super Mex and Power Mix as well as their interaction on some vegetative growth parameters, seed yield, fixed oil production and chemical compositions of black cumin (*Nigella sativa* L.) plants. Seeds of black cumin were obtained from the Medicinal and Aromatic Plants Section of Agric. Res. Center, El-Dokki, Cairo, Egypt. Soil analysis before the application of any fertilizers (mechanical and chemical analysis) is shown in Table (A).

Table (A): Chemical and physical analysis of experimental soil.

Properties		1st season	2nd season
Mechanical analysis (%)	Corse sand	2.71	2.87
	Fine sand	29.23	29.09
	Silt	33.90	33.98
	Clay	34.16	34.06
	T. class	sand clay loam	sand clay loam
Chemical Analysis	PH	7.84	7.95
	Ec 1:5 ds / m	1.13	1.22
	Ca Co_3 (%)	3.16	2.98
	O.M (%)	1.35	1.49
	SP	58	59
Available nutrients (ppm)	N	49.7	53.8
	P	5.16	4.97
	K	288	275

The field was divided to experimental plots, each one was 3.5 m^2 (2 x 1.75 m), each plot contained 3 rows, the distance between hills was 25 cm, every hill contained 2 plants and each plot contained from 30 plants. The transplants were thinned to 2 plants /hill after 45 days from sowing. Seeds were sown on 9th of October during the two winter seasons.

Fertilization:

Mineral fertilizers was added to control plants at the rate of 200 kg / fed of ammonium nitrate (33.5 %N), 200kg / fed calcium superphosphate (15.5 % P_2O_5) and 100 kg / fed potassium sulphate (48 % K_2O). These previous quantities were added at 50 % NPK in all treatments except for the control plants.

The amounts of mineral PK was added during preparing the soil in the two seasons and ammonium nitrate was divided to three batches and added at one month interval, starting 25th November, in both seasons. All agricultural practices were carried out as usual in the two growing seasons.

Natural sources of phosphorus were Phosphorien and Rock phosphate. Phosphorien (commercial name) contains live cells of efficient bacteria strain (*Bacillus megatherium*) as phosphate solubilizing bacteria was divided to three levels of 100, 75 and 50 % of RD 8.33, 6.25 and 4.17 g/ plot.

Biofertilizers were provided by the General Organization for Agriculture Equalization Fund (G.O.A.E.F.), Ministry of Agriculture, Egypt. Rock phosphate added at the rate of 200 kg / fed during preparing the soil in the two seasons. It was divided to three levels of 100, 75 and 50 % of recommended dose (175, 131.25 and 87.5 g/ plot) and was obtained from Al-Gomhoria Company

The foliar application was done using Super Mex or Power Mix. Super Mex consists of micro elements, amino acids, Mn, Ca, vitamins and organic acids and was applied at the concentration of 8.3 cm^3/L. Power Mix consists of amino acids (21 %), potassium citrate (4.5 %), microelements (3.5 %), riboflavin (3 %), cytokinin (0.3 %), gibberllic acid (0.001 %), inert ingredients (32 %), natural oxen, and vitamins was applied at the concentration of 1.5 cm^3 /L. Foliar sprays were supplied three times; at vegetative, flowering and fruitage stages using a small hand sprayer obtained from General Organization for Agriculture Equalization Fund (G.O.A.E.F.), Ministry of Agriculture, Egypt.

Experimental design:

The experimental design was factorial experiment in randomized complete block design twelve treatments including with three replicates as follows**:**

- 100 % NPK (Control).
- 50 % (Phosphorien + Rock phosphate) + 50 % NPK (RD).
- 75 % (Phosphorien + Rock phosphate) + 50 % NPK (RD).
- 100 % (Phosphorien + Rock phosphate) + 50 % NPK (RD).
- Super Mex (RD) + 50 % NPK (RD).
- Power Mix (RD) + 50 % NPK (RD).
- 50 % (Phosphorien + Rock phosphate) + Super Mex + 50 % NPK.
- 75 % (Phosphorien + Rock phosphate) + Super Mex + 50 % NPK.
- 100 % (Phosphorien +Rock phosphate) + Super Mex + 50 % NPK.
- 50 % (Phosphorien + Rock phosphate) + Power Mix + 50 % NPK.
- 75 % (Phosphorien + Rock phosphate) + Power Mix + 50 % NPK.
- 100 % (Phosphorien + Rock phosphate) + Power Mix + 50 % NPK.

Data recorded :

Black cumin plants were collected at the harvest date after seven months from sowing on 9th May in both seasons. Six plants were randomly collected from each treatment and the following characters were recorded:

1- **Vegetative growth characters**: Plant height (cm), plant weight (g), capsules number/ plant and seed number/ capsule.
2- **Seed yield**: Weights (g) of capsules/ plant, 1000-seed, seed yield/ plant and kg/ fed
3- **Fixed oil productivity**: Fixed oil (%) and yield (L/ fed). was estimated as described by Munshi (1987). Powder of each sample was extract using a solvent hexan.
4- **Chemical constituents**: N, P, K, Fe, Zn and Cu (%) in seeds.

Chemical analysis:

For determination of macro and micro elements; 0.2 g crude powder from each sample was digested with a mixture of concentrated sulphoric acid and perchloric acid, then heated until become clear solution and transferred into 50 ml measuring flask with distilled water as described by Peterburgski (1968). Nitrogen (%) was determined according to A.O.A.C. (1984).

Phosphorus (%) was determined spectro- photomitrically as described by Jackson (1973). Potassium (%) was estimated using Flame photometer model according to Peterburgski (1968). Fe, Zn and Cu percentages were estimated in seeds using atomic absorption spectrophotometer according to the methods of Chapman and Pratt (1982).

Statistical analysis:

Collected data were subjected to the statistical analysis according to the technique of variance (ANOVA) of factorial experiment in RCB design. The treatments means were compared using the least significant differences (L.S.D) at .5 % procedure as mentioned by Gomez and Gomez, (1984).

RESULTS AND DISCUSSIONS

Vegetative growth characters:

Effect of natural sources of phosphorus:

From data in Table (1), the treatment of Phosphorien plus Rock phosphate at rates of 50, 75 and 100 % significantly affected the vegetative growth characters of black cumin as compared with the non-treated ones. The highest values of plant height (125.6 and 135.7cm), capsules number/ plant (163.8 and 166.2 capsule) and seeds number/capsule (105.7 and 106.2 seeds) were obtained from the treatment of 50 % (Phosphorien plus Rock phosphate) + 50 % NPK**,** but the heaviest plant weight (132.0 and 133.6 g) was obtained from the treatment of 75 % (Phosphorien plus Rock phosphate) + 50 % NPK in the two seasons, respectively While, the least values of all vegetative growth characters were plant height (114.3 and 125.9 cm), plant weight (106.2 and 98.2 g), capsules number/ plant (126.1 and 111.1 capsule) and seeds number/ capsule (98.8 and 99.3 seed) recorded from the control plants in the two seasons, respectively. Therefore, it appears that some kinds of bacteria in the biofertilizer produce gibberellin which increases the length of the individual internode. The increase in number of capsules per plant by the inoculation with phosphate solubilizing microorganisms can be dissolved problem and made available to plants by soil rhizophere microoganismms through the production of organic acids, (Johri *et al*., 1999).

The stimulatory effect of phosphorus on plant growth may be due to that phosphorus play important role in a positive impact on plant growth. The increase in plant height may be a result of both the greater number of cells formed and an increased elongation of the individual cell (EL-Kramany *et al*., 2000). The highest values of the vegetative growth by biofertilizers may be due to the increase in phosphorus from phosphate dissolving bacteria as well as growth promoting substances such as IAA and GA produced by organisms Sakr (2005).

These results are similar to those reported by Shalan (2005) on *Nigella sativa* L. plants, Massoud (2007) on marjoram and Abd El-Naeem (2008) on caraway.

Table (1): Effect of natural sources of phosphorus and foliar spray on plant height (cm), plant weight (g), capsules number/ plant and seeds number/capsule of black cumin during (2011/2012 and 2012/2013) seasons.

Treatments	Plant height (cm)		Plant weight (g)		Capsules number/ plant		Seed number/ capsule	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
A = Effect of natural sources of phosphorus								
100 % NPK (Control)	114.3	125.9	106.2	98.2	126.1	111.1	98.8	99.3
50 % (Phos.+Rock)+ 50 % NPK	125.6	135.7	120.6	126.7	163.8	166.2	105.7	106.2
75 % (Phos.+ Rock)+ 50 % NPK	118.1	132.3	132.0	133.6	127.7	131.7	102.9	103.4
100 % (Phos.+Rock)+ 50 % NPK	116.3	127.3	107.4	123.7	155.2	151.3	102.9	105.1
L.S.D. at 5 %	11.9	18.5	31.0	1.6	42.9	11.6	7.5	7.5
B = Effect of foliar application								
Control 100 % NPK	114.3	125.9	106.2	98.2	126.1	111.1	98.8	99.3
Super Mex (RD) + 50 % NPK	120.2	134.3	118.3	134.3	144.8	167.5	106.8	107.4
Power Mix (RD) + 50 % NPK	119.2	133.8	116.6	133.8	143.9	134.3	102.7	104.2
L.S.D. at 5 %	10.3	16.0	26.9	1.4	37.1	10.1	6.5	6.5
The interaction treatments (A x B)								
Control 100 % NPK	114.3	125.9	106.2	98.2	126.1	111.1	98.8	99.3
50 % (Phos.+ Rock)+ Super Mex + 50 % NPK	128.7	140.2	134.0	154.0	162.2	185.3	111.8	111.2
75 % (Phos.+ Rock) + Super Mex + 50 % NPK	129.3	141.8	140.5	164.9	175.3	206.8	116.2	115.8
100 % (Phos.+ Rock) +Super Mex + 50 % NPK.	118.7	132.7	101.3	100.8	153.8	133.7	108.3	104.3
50 % (Phos.+ Rock) + Power Mix + 50 % NPK	117.7	119.2	117.4	85.4	120.3	106.0	105.8	105.5
75 % (Phos.+ Rock) + Power Mix + 50 % NPK	116.5	124.0	101.3	100.8	151.2	139.7	97.7	97.0
100 % (Phos.+ Rock) + Power Mix + 50 % NPK	116.5	130.5	120.4	122.6	148.8	130.5	107.7	106.3
L.S.D. at 5 %	20.6	32.0	53.7	2.7	74.2	20.1	12.9	12.9

Phos. = Phosphorien Rock = Rock phosphate

Effect of some foliar applications:

Results from data in Table (1) indicated that the effect of foliar spray with Super Mex at recommended dose (RD) gave a significant superiority on vegetative growth characters than foliar spray with Power Mix compared to control plants (unsprayed plants) in the two seasons. The results show that the highest values of plant height (120.2 and 134.3 cm), plant weight (118.3 and 134.3 g), capsules number / plant (144.8 and 167.5 capsule) and seeds number/capsule (106.8 and 107.4 seed) were recorded from spraying plants with Super Mex + 50 % NPK respectively, in the two seasons. While, the least values were (116.3 and 122.6 cm) of plant height, plant weight (114.7 and 122.6), capsules number/ plant (140.9 and 118.4 capsule) and seeds number/ capsule (98.3 and 98.9 seed) came from control plants in the two seasons, respectively. Samiullah *et al.* (1988) indicated that various physiological processes, e.g. nutrient uptake, respiration, photosynthesis depend more or less on the availability of B vitamin. The stimulatory effect of foliar spray on vegetative growth characters may be attributed to the presence of macro and micronutrients, i.e., N, Mg, B, S and Mo in yeast (Nagodawithana, 1991). These several vitamins, proteins, amino acids and nutritional elements (Na, Ca, Fe, Mg, K, P, S, Zn and Si) were in both Super Mex and Power Mix.

These results are in agreement with those reported by Abd El-Wahab (2008) on *Trachyspermum ammi* L. plant and Ghally and El-Sodany (2009) on *Niglla sativa* L. plants.

Effect of the interaction treatments:

Regarding the data presented in Table (1), there was significant differences as affected by the interaction treatments between natural sources of Phosphorus fertilization at rates of (50, 75 and 100 %) and foliar spray application of Super Mex and Power Mix in (RD) in comparison with the control plants (100 % NPK) on vegetative growth characters of black cumin.

The treatment of 75 % (Phosphorien + Rock phosphate) + Super Mex + 50 % NPK gave the superiority effect of vegetative growth characters such as the tallest plants (129.3 and 141.8 cm), the heaviest weight (140.5 and 164.9 g/ plant), the highest capsules number/ plant (175.3 and 206.8 capsule) and the highest seeds number / capsule (116.2 and 115.8 seed) in the two seasons respectively, followed by the treatment of 50 % (Phosphorien + Rock phosphate) + Super Mex + 50 % NPK without significant differences. While, the shortest plants (107.5 and 114.7 cm), the lightest plant weight (95.5 and 76.3 g), the least number of capsules/ plant (99.7 and 85.2 capsule) and the least number of seeds / capsule (95.8 and 96.2 seed) in the two seasons respectively, were resulted from the control plants.

The stimulatory effect of the interaction treatments may be attributed to the co-operation of principal components of these fertilizers which consisted useful relationship that led to healthy and vigorous growth. Phosphorein has enormous potential to solubilize about 50-60 % of solubile phosphorus in the soil by secreting organic acids within a short time, Vyas and Vyas (1994). The superior effect of foliar application could be attributed to contents of micro elements, trace element, group of amino acids, magnesium, calcium, vitamins and organic acids.

Similar results were obtained by Ghally and Abd El-sayed (2009) on *Cyamposis tetragonoloba* plants and Abdou *et al.* (2011) on clove basil.

Seed yield:

Effect of natural sources of phosphorus:

It is clear from data shown in Table (2) that all treatments of Phosphorien plus Rock phosphate at rates of 50, 75 and 100 % of recommended dose had an markedly effect on seed weight.

The heaviest capsules weight /plant (43.10 and 45.92 g), 1000-seed weight (4.14 and 3.25 g), the heaviest seed yield (19.95 and 19.15 g / plant) and (866.2 and 832.0 kg/fed) were resulted from the treatment of 50 % (Phosphorien + Rock phosphate) + 50 % NPK in the both seasons, respectively. The least values of capsules weight (31.10 and 25.00 g/ plant), 1000 seed weight (3.91 and 2.84 g), and seed yield (10.42 and 7.52 g/ plant) and (452.4 and 327.0 kg/fed) were resulted from the control plants in the both seasons, respectively. The increase in weight of seed with Phosphorein inoculation might be due to that phosphorus encouraged plant to stimulate flowering and improve quality and quantity of the seeds and it is necessary for protoplasm formation and yield (Ali, 2001). The increase in seed yield with bio-fertilizers may be related to the action of the biofertilizer which resulting an increase in the vegetative growth and shortening the period required to reach flowering, thus increasing seed production, (Sakr, 2005).

Such results were the findings of Shalan (2005) on *Nigella sativa* L. plants and Abd El-Naeem (2008) on caraway.

Effect of some foliar applications:

Results in Table (2) achieved that seed weight was affected by foliar spray with Super Mex and Power Mix at recommended dose. It is quite evident that all treatments significantly increased the weight of seeds in both seasons. The heaviest capsules weight (37.80 and 44.66 g /plant), 1000-seed weight (4.07 and 3.27 g), seed yield (17.79 and 16.92 g/ plant) and (722.8 and 735.0 kg/ fed) were resulted from the foliar spray treatment with Super Mex + 50 % NPK respectively, in the two seasons. The least values resulted from the control treatment at 100 % NPK were (34.60 and 28.66 g / plant) capsules weight, (3.98 and 2.80 g) were 1000-seed weight and seed yield (11.68 and 9.83 g/ plant) and (507.2 and 427.0 kg/ fed) in the both seasons, respectively. Such results indicated that the role of foliar spray is improving vegetative growth through its effect on increasing nutrients availability, increasing soil P; K; accelerating, cell division and root system development (Schnitzer and Shinner, 1962). The positive action of foliar spray and its contents of various nutrients could be attributed to its content of cytokinins and vitamin B as well as its important role on building up carbohydrates. The auxinic action of ascorbic acid as antioxidant as well as its effect on enhancing the biosynthesis of carbohydrates could explain the present results. The stimulating action of sulpher on the biosynthesis of proteins and the formation of roots could explain the present results. These previous benefits of these materials surely reflected on enhancing both cell division and cell enlargement, (Nijjar, 1985).

These results coincided with those obtained by Mohamad and Naguib (2002) on fenugreek and Naguib and Khalil (2002) on black cumin.

Effect of the interaction treatment:

Results established in Table (2) showed significantly effect of the interaction treatments between natural sources of phosphorus and some foliar application on the seed weight. The superiority values of capsules weight (46.60 and 56.98 g / plant), of 1000-seed weight (4.32 and 3.50 g) came from the treatment of 75 % (Phosphorien + Rock phosphate) + Super Mex + 50 % NPK**,** while the heaviest seed yield resulted from the treatment 50 %

(Phosphorien plus Rock phosphate) + Super Mex + 50 % NPK was (21.24 and 20.60 g/ plant) and (922.3 and 895.0 kg/ fed) in the two seasons, respectively. The lightest weight of capsules (24.40 and 20.79 g/ plant), 1000 seed weight (3.76 and 2.34 g), seed yield (8.12 and 6.11 g/ plant) and (352.5 and 265.0kg/ fed) were recorded from the control plants respectively, in the both seasons. The positive effect of these combinations may be attributed to the activation role of Phosphorein which causing most soil fertility which influences plant metabolism and makes the nutrients in the soil more available by its chelating capacity with micronutrients (Schnitzer and Shinner, 1962).

Table (2): Effect of natural sources of phosphorus and foliar application on weights of capsules (g/ plant), 1000-seed (g), seed (g/ plant) and (kg/ fed) of black cumin during (2011/2012 and 2012/2013) seasons.

Treatments	Weights (g)						Weights (kg)	
	Capsules/ plant		1000-seed		Seed yield/ plant		Seed yield/ fed	
	1st season	2nd season	1st season	1st season	1st season	2nd season	1st season	2nd season
A = Effect of natural sources of phosphorus								
100 % NPK (Control)	31.10	25.00	3.91	2.84	10.42	7.52	452.4	327.0
50 % (Phos.+ Rock) + 50 % NPK	43.10	45.92	4.14	3.25	19.95	19.15	866.2	832.0
75 % (Phos.+ Rock) + 50 % NPK	38.90	43.57	4.04	3.19	14.43	13.13	626.8	570.0
100 % (Phos+ Rock) + 50 % NPK	31.70	33.39	4.00	2.89	13.42	12.60	582.8	547.0
L.S.D. at 5 %	15.03	3.69	0.34	0.26	2.19	2.02	95.2	87.6
B = Effect of foliar application								
Control 100 % NPK	31.10	25.00	3.91	2.84	10.42	7.52	452.4	327.0
Super Mex (RD) + 50 % NPK	37.80	44.66	4.07	3.27	17.79	16.92	772.8	735.0
Power Mix (RD)+ 50 % NPK	36.10	37.60	4.02	3.07	14.19	12.55	616.0	545.0
L.S.D. at 5 %	13.02	3.20	0.30	0.23	1.90	1.75	82.5	75.8
The interaction treatments (A x B)								
Control 100 % NPK	31.10	25.00	3.91	2.84	10.42	7.52	452.4	327.0
50 % (Phos.+Rock) +Super Mex + 50 % NPK	42.70	53.89	4.13	3.09	21.24	20.60	922.3	895.0
75 % (Phos.+ Rock)+ Super Mex + 50 % NPK	46.60	56.98	4.32	3.50	18.59	18.14	807.5	788.0
100 % (Phos.+Rock)+Super Mex + 50 % NPK.	37.60	37.88	4.00	3.18	19.79	19.79	859.6	860.0
50 % (Phos.+ Rock)+ Power Mix + 50 % NPK	33.20	31.83	4.04	3.16	14.25	13.73	619.0	596.0
75 % (Phos.+ Rock)+ Power Mix + 50 % NPK	36.40	28.50	4.03	3.08	9.76	8.04	423.9	349.0
100 % (Phos.+Rock)+Power Mix + 50 % NPK	34.90	29.97	4.15	2.98	11.13	10.26	483.2	446.0
L.S.D. at 5 %	26.04	6.39	0.60	0.46	3.8	3.5	164.9	151.7

Phos. = Phosphorien   Rock = Rock phosphate

It may be mentioned that many workers previously came to a similar conclusion Ghally and Abd El-Sayed (2009) on *Cyamposis tetragonoloba* plant and Abdou *et al.* (2011) on clove basil.

Fixed oil productivity:

Effect of natural sources of phosphorus:

Data in Table (3) achieved significantly differences from the natural sources of phosphorus on fixed oil productivity of black cumin during the two seasons. The highest fixed oil percentage was (31.8 and 29.9 %) and oil yield (273.6 and 246.7 L/ fed) respectively, in the two seasons resulted from the treatment of 50 % (Phosphorien + Rock phosphate) + 50 % NPK**.** While, the least values was (29.5 and 27.8 %) and (133.5 and 90.8 L/ fed) in the both seasons respectively, resulted from the control plants.

From these results, it may be concluded that fixed oil productivity was influenced by natural sources of phosphorus fertilization. The increase in fixed oil yield may be due to the increase in seed yield, as well as the concerning effect of co-operation roles for biofertilizer solely or their combinations. These results were supported with those of Ahmed (2007) and Ghally and El-Sodany (2009) on *Niglla sativa* L. plants and Abdou *et al.* (2011) on clove basil.

Effect of some foliar application:

Effect of foliar application with Super Mex and Power Mix at recommended dose on fixed oil yield was represented in Table (3).

The highest oil percentage was (31.8 and 29.9 %) and oil yield (248.1 and 221.9 L/ fed) recorded from the sprayed plants with the treatment of Super Mex + 50 % NPK in the two seasons, respectively**.** The least values of oil percentage and yield was (30.4 and 28.6 %) and (153.9 and 122.0 L / fed) which from the sprayed plants with the treatment of Power Mix + 50 % NPK in the two seasons, respectively. The increase in fixed oil productivity as a result of application of Super Mex consists of micro elements, group of amino and organic acids, Mg and Ca might be due to the combination effect of these elements and their role on plant growth and formation of fixed oil as previously mentioned. The effect of foliar application with some microelements on oil productivity in different plants was studied by many investigators; such as Ghally and El-Sodany (2009) on *Niglla sativa* L. plants and Sharaf–El-Deen *et al.* (2012) on *Foeniculum vulgare* Mill. plants, who stated that spraying plants with microelements caused significant enhancement in oil yield.

Effect of the interaction treatments:

In the same Table, results cleared that the interaction between natural sources of phosphorus and foliar application with Super Mex and Power Mix at recommended dose (RD) significantly affected fixed oil productivity of black cumin.

The highest fixed oil percentage was (32.8 and 30.8 %) and fixed oil yield (333.9 and 298.7 L/ fed) resulted from the treatment of half dose of NPK + Super Mex + 75 % (Phosphorien + Rock phosphate) followed by the same treatment with 50 % (Phosphorien + Rock phosphate) in the first and second seasons, respectively.

Table (3): Effect of natural sources of phosphorus and foliar application on fixed oil (%) and yield (L/ fed) of black cumin during (2011/2012 and 2012/2013) seasons.

Treatments	Fixed oil			
	(%)		Yield (L / fad)	
	1st season	2nd season	1st season	2nd season
A = Natural sources of phosphorus				
100 % NPK (Control)	29.5	27.8	133.5	90.8
50 % (Phos. + Rock) + 50 % NPK	31.8	29.9	273.6	246.7
75 % (Phos. + Rock) + 50 % NPK	31.6	29.7	200.4	171.8
100 % (Phos. + Rock) + 50 % NPK	31.4	29.5	185.3	163.4
L.S.D. at 5 %	0.04	0.09	29.0	25.9
B = Foliar application				
Control 100 % NPK	29.5	27.8	133.5	90.8
Super Mex (RD) + 50 % NPK	31.8	29.9	248.1	221.9
Power Mix (RD) + 50 % NPK	30.4	28.6	153.9	122.0
L.S.D. at 5 %	0.03	0.08	25.1	22.4
The interaction treatments (A x B)				
Control 100 % NPK	29.5	27.8	133.5	90.8
50 % (Phos.+ Rock) +Super Mex +50 % NPK	32.5	30.5	299.5	272.4
75 % (Phos.+ Rock) +Super Mex +50 % NPK	32.8	30.8	333.9	298.7
100 % (Phos.+ Rock)+Super Mex+50 % NPK	32.3	30.3	278.9	260.7
50 % (Phos.+ Rock) +Power Mix +50 % NPK	30.3	28.4	187.4	169.1
75 % (Phos.+ Rock)+ Power Mix +50 % NPK	30.7	28.8	129.9	100.7
100 % (Phos.+ Rock)+ Power Mix+50 % NPK	31.0	29.2	149.9	130.2
L.S.D. at 5 %	0.07	0.16	50.3	44.8

Phos. = Phosphorien Rock = Rock phosphate

While, the least values resulted from the full dose of NPK (control) were (29.2 and 27.4 %) and (102.8 and 72.6 L/ fed) in the two seasons, respectively. These results may be explained on the basis that oil yield was influenced by the synergetic effect inoculated plants by natural sources of phosphorus (Phosphorien + Rock phosphate) in addition to the effect of microelements. These results are in harmony with Abdou *et al.* (2011) on clove basil and Sakr *et al.* (2012) on *Majorana hortensis* L. plants.

Chemical constituents:

Effect of natural sources of phosphorus:

It is evident from results in Table (4) that all used treatments of Phosphorien plus rock phosphate at rates of 50, 75 and 100 % had significant effect on the chemical constituents (macro and micro elements) in seeds of black cumin. The highest values of macro elements percentages of N, P and K and microelements of Fe, Zn and Cu in seeds of black cumin produced from the treatment of 75 % (Phosphorien + Rock phosphate)+ 50 % NPK were (3.81 and 3.61 N), (0.541 and 0.595 P), (0.231 and 0.292 K), (0.105 and 0.100 Fe), (0.064 and 0.057 Zn) and (0.022 and 0.018 Cu) in the both seasons, respectively.

While, the least values were (3.45 and 3.28 N), (0.528 and 0.581 P), (0.225 and 0.213 K), (0.099 and 0.093 Fe), (0.059 and 0.052 Zn) and (0.018

and 0.015 Cu) which resulted from the control treatment in the two seasons, respectively.

The positive effect of Phosphorien may be due to the role of Phosphorus in photosynthesis in addition to its roles in cell division and development of merestematic tissues. The protective effects of NPK treatment and the treatment of biofertilizers + salicylic acid in promoting the vegetative growth may be attributed to the increasing of N, P and K in root zone from N, consequently increase formation of metabolites which encourage the plant growth, (Sprent, 1990). The combination between mineral fertilizer and inoculation Mexico bean seeds with *Rhizobium* plus Phosphorein together resulted significantly the highest values of N, P and K %, El-Shamma (2000).

These findings are in agreement with Ghally and Abd El-Sayed (2009) on guar and Sakr *et al.* (2012) on marjoram, who reported that, the highest values of N, P and K in the plants were recorded for the treatment of biofertilizer plus dose of N and P than the other treatments.

Effect of some foliar applications:

As regarding data in Table (4) there was a significant effect of the two foliar spray treatments at recommended dose on total N, P, K, Fe, Zn and Cu (%) in seeds of black cumin.

The highest values resulted from the treatment of foliar spray with Super Mex at recommended dose + 50 % NPK were (3.84 and 3.65 % N), (0.542 and 0.596 % P), (0.232 and 0.219 % K), (0.106 and 0.101 % Fe), (0.064 and 0.056 % Zn) and (0.022 and 0.018 % Cu) in the both seasons, respectively. While, the least values resulted from the treatment of Power Mix + 50 % NPK were since (3.57 and 3.50% N), (0.532 and 0.586% P), (0.227 and 0.215% K), (0.102 and 0.095% Fe), (0.060 and 0.053% Zn) and (0.019 and 0.016% Cu) in the both seasons, respectively.

These results were in harmony with those obtained by Ghally *et al*. (2003) on caraway and Abd EL-Wahab (2008) on *Trachyspermum ammi* L. plants. They found that spraying plants with microelements resulted in significant enhancements of NPK conten.

Effect of the interaction treatments:

Data in the same Table achieved a significantly effect of the interaction between inoculation with natural sources of phosphorus and foliar application on N, P, K, Fe, Zn and Cu percentages in black cumin seeds.

Plants inoculated by 75 % (Phosphorien + Rock phosphate) and sprayed with Super Mex at recommended dose + half dose of NPK gave the highest percentages of (4.01 and 3.81 N), (0.549 and 0.602 P), (0.235 and 0.223 K), (0.109 and 0.103 Fe), (0.067 and 0.059 Zn) and (0.024 and 0.020 Cu) in the both seasons, respectively. While, the full dose of NPK produced the least percentages of (3.41 and 3.23 N), (0.528 and 0.580 P), (0.224 and 0.212 K), (0.098 and 0.092 Fe), (0.057 and 0.050 Zn) and (0.017 and 0.015 Cu) in the both seasons, respectively.

These results were in accordance with those obtained by some workers on different plants; such as Massoud (2006) on *Salvia officinalis* plants, Ghally and Abd El-Sayed (2009) on guar or cluster bean (*Cyamposis tetragonoloba*) plant and Sakr *et al.* (2012) on *Majorana hortensis* plant.

It can be concluded and recommended that treating plants by 50 % (Phosphorien + Rock phosphate) and sprayed with Super Mex + half dose of NPK produced the best vegetative growth parameters, seed yield, fixed oil percentage, yield and chemical compositions of *Nigela sativa* L. plants.

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استجابة نبات حبة البركة لبعض المصادر الطبيعية للفوسفور ومواد الرش الورقى

حكمـــت يحيـــى مســـعود*، علـــى منصـــور حمـــزة *، شـــادية قطـــب أحمـــد **و منال محمد مليجى نبوى **

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**** قسم بحوث النباتات الطبية والعطرية – معهد بحوث البساتين – مركز البحوث الزراعية**

أجريت التجربة فى المحطة البحثية بالجميزة – مركز البحوث الزراعية - محافظة الغربية خلال موسمين زراعيين شد تويـ ين متتاليين (٢٠١١/ ٢٠١٢ و ٢٠١٢ / ٢٠١٣) بهدف دراسة تأثير استخدام مصادر طبيعية للفوفسفور(الفوسفورين مع سماد صخر الفوسفات) بالاضافة الى مواد الرش الورقى (السوبر ميكس و الباور ميكس) والتفاعل بينهما على بعض صفات النمو الخضرى ومحصول البذرة ومحصول الزيت الثابت والمحتوى الكيميائى لنباتات حبة البركة.

وكانت النتائج المتحصل عليها كما يلى:-

١- أعطت معاملة ٥٠ % من (الفوسفورين مع سماد صخر الفوسفات) + ٥٠ % من النتروجين والفوسفور والبوتاسيوم من المعدل الموصى به زيادة معنوية فى صفات النمو الخضرى ومحصول البذور والزيت الثابت خلال موسمى الزراعة بينما أعطت معاملة ٧٥ % من (الفوسفورين مع سماد صخر الفوسفات) + ٥٠ % من النتروجين والفوسفور والبوتاسيوم زيادة معنوية فى الوزن الجاف للنبات والمحتوى الكيماوى من العناصر الكبرى والصغرى فى البذرة خلال موسمى الزراعة.

٢- أعطت معاملة الرش الورقى بمركب السوبر ميكس بالمعدل الموصى به + نصف المعدل الموصى به من النتروجين والفوسفور والبوتاسيوم زيادة معنوية فى كل الصفات المدروسة خلال موسمى الزراعة.

٣- أعطت معاملة التفاعل ٧٥ % (الفوسفورين مع سماد صخر الفوسفات) + الرش الورقى بالسوبر ميكس + ٥٠ % من النتروجين والفوسفور والبوتاسيوم زيادة معنوية فى كل صفات النمو الخضرى و محصول الزيت الثابت والمحتوى الكيماوى من العناصر الكبرى والصغرى فى البذرة خلال موسمى الزراعة. بينما أعطت معاملة ٥٠ % (الفوسفورين مع سماد صخر الفوسفات) + ٥٠ % من النتروجين والفوسفور والبوتاسيوم زيادة معنوية فى الوزن الجاف للنبات خلال موسمى الزراعة.

يمكن التوصية بإستخدام مصادر طبيعية للفوسفور من الفوسفورين مع سماد صخر الفوسفات بتركيز ٥٠ % مع الرش الورقى بمركب السوبر ميكس بالمعدل الموصى به مع نصف الجرعة من السماد المعدنى أعطت أعلى زيادة معنوية فى صفات النمو الخضرى ومحصول البذور ومحصول الزيت الثابت و المحتوى الكيميائى للعناصر الكبرى والصغرى فى نباتات حبة البركة. وبذلك يمكن توفير نصف نفقات السماد المعدنى مع الزيادة فى عناصر النمو فى نفس الوقت.

Table (4): Effect of natural sources of phosphorus and foliar application on chemical constituents (%) in seeds of black cumin during (2011/2012 and 2012/2013) seasons.

Treatments	Chemical constituents (%)											
	N		P		K		Fe		Zn		Cu	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1s season	2nd season	1st season	2nd season
A = Natural sources of phosphorus												
100 % NPK (Control)	3.45	3.28	0.53	0.58	0.23	0.21	0.10	0.09	0.06	0.05	0.02	0.02
50 % (Phos. + Rock) + 50 % NPK	3.76	3.59	0.54	0.59	0.23	0.22	0.11	0.10	0.06	0.06	0.02	0.012
75 % (Phos. + Rock) + 50 % NPK	3.81	3.61	0.54	0.60	0.23	0.22	0.11	0.10	0.06	0.05	0.02	0.02
100 % (Phos. + Rock) + 50 % NPK	3.75	3.57	0.54	0.59	0.23	0.22	0.11	0.10	0.06	0.06	0.02	0.02
L.S.D. at 5 %	**0.01**	**0.04**	**0.0023**	**0.0024**	**0.0012**	**0.0011**	**0.0013**	**0.0011**	**0.0012**	**0.0011**	**0.0010**	**0.0010**
B = Foliar application												
Control 100 % NPK	3.45	3.28	0.53	0.58	0.23	0.21	0.10	0.09	0.06	0.05	0.02	0.02
Super Mex (RD) + 50 % NPK	3.84	3.65	.054	0.60	0.23	0.22	0.11	0.10	0.06	0.06	0.02	0.02
Power Mix (RD)+ 50 % NPK	3.57	3.50	0.53	0.59	0.23	0.22	0.10	0.10	0.06	0.05	0.02	0.02
L.S.D. at 5 %	**0.01**	**0.03**	**0.0020**	**0.0023**	**0.0011**	**0.0010**	**0.0011**	**0.0010**	**0.0014**	**0.0012**	**0.001**	**0.0010**
The interaction treatments (A x B)												
Control 100 % NPK	3.45	3.28	0.53	0.58	0.23	0.21	0.10	0.09	0.06	0.05	0.02	0.02
50 % (Phos. +Rock)+Super Mex+50 % NPK	3.97	3.79	0.55	0.60	0.23	0.22	0.11	0.10	0.07	0.06	0.02	0.02
75 % (Phos.+Rock)+Super Mex+50 % NPK	4.01	3.81	0.55	0.60	0.24	0.22	0.11	0.10	0.07	0.06	0.02	0.02
100 % (Phos.+Rock)+Super Mex+50% NPK	3.89	3.69	0.54	0.60	0.23	0.22	0.11	0.10	0.06	0.06	0.02	0.02
50 % (Phos. +Rock)+Power Mix+ 50 % NPK	3.55	3.40	0.53	0.59	0.23	0.22	0.10	0.09	0.06	0.05	0.02	0.02

75 % (Phos. + Rock) +Power Mix+50% NPK	3.61	3.40	0.54	0.59	0.23	0.22	0.10	0.01	0.06	0.05	0.02	0.11
100 % (Phos.+Rock)+Power Mix+50 % NPK	3.65	3.48	0.54	0.59	0.23	0.22	0.10	0.10	0.06	0.06	0.02	0.017
L.S.D. at 5 %	**1.87**	**0.06**	**0.018**	**0.016**	**0.015**	**0.013**	**0.012**	**0.011**	**0.006**	**0.006**	**0.006**	**0.005**

Phos. = Phosphorien Rock = Rock phosphate